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Release Mechanism for Releasing and Reattaching Experiments on the Space Shuttle

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TECHNICAL PAPER

RELEASE MECHANISM FOR RELEASING AND REATTACHING EXPERIMENTS ON THE SPACE SHUTTLE

INTRODUCTION

The Release Mechanism (REM) (Fig. 1) was designed for the Induced Environmental Contamination Monitor (IECM) to release the IECM so that it could be moved about inside and outside the Shuttle bay by the remote manipulator system (RMS) to check for contamination. The REM releases the IECM scientific package structurally and electrically from the development flight instrumentation (DFI) pallet; and after the IECM has completed its contamination monitoring, the REM reattaches the IECM structurally and electrically to the DFI pallet. To release the experiment, the REM is operated from the crew compartment after the RMS has been attached to the experiment. The REM releases the experiment by one of two electric motors driving a gear train and linkage which extract four pins from four plates. The REM separable electrical connectors are disengaged by the same mechanical action of the structural pins retracting from the plates.

If one electric motor fails the other motor is used, since either motor independently drives the gear train through a differential.

When the REM has released the experiment, an unlatched indicator is actuated in the crew compartment, and then the experiment can be moved with the RMS.

To reattach the experiment to the REM, the RMS places the experiment with REM attachment angles against the flat smooth surface of the REM; then the RMS slides the angles against a side guide, then along the guide until hooks on one angle engage monoballs on the REM linkage. Locating the experiment for reattachment is equivalent to finding the corner of a room in the dark where you are standing on the floor and walk to a wall, then follow the wall to a corner (another wall).

When the REM is in the "corner" or ready to latch position, position switches on the REM will provide indications in the crew compartment as to the experiment position relative to the REM. If the position switches are not actuated, the operator, using the RMS, moves the experiment until the six position switches indicate that the REM is ready to latch. Then actuation of either of the electric motors drives the four pins into the holes in the plates. When fully latched, a switch actuated by the motion of the linkage shuts the electric motor off and gives an indication to the crew compartment that the REM is latched.

The REM was designed specifically for the IECM experiment. It was based upon a mechanism designed by Martin Marietta Company on an MSFC contract. It had major known design restraints of size because of the location of the IECM on the Shuttle DFI pallet. It was not originally designed for manual operation of the RMS with TV feedback to the crew. When this became the primary RMS mode of operation, the REM was redesigned with a paint pattern to aid the crew in locating the experiment on the REM base.

GENERAL SCIENCE USAGE

The REM is a versatile separation device which can be used on many experiment packages which require release from the Shuttle and/or reattachment to it. For Spacelab II it will release the plasma diagnostic package (PDP) which will remain in orbit. It has been proposed to release and reattach the experiment packages which will be using the annular suspension and pointing gimbal system (AGS).

The REM would be redesigned to meet the requirement of the AGS experiment packages. This would primarily be a change in size, i.e., strength, for larger experiments. Since the AGS will be pivoted from one point, the REM landing surfaces would be reduced in size; and possibly the present 1.85 in. of travel during latching would be reduced to match that allowed (approximately 1 in.) by the AGS.

FUTURE USAGE

The REM could be designed with replaceable parts for use with various payloads. The replaceable parts would be selected to fit or be fitted for the particular shape and size of the experiment. This REM future design would allow experimenters to select a release mechanism that was inexpensive and that would have a short production time. The REM could accommodate different weights from 100 lb to several thousand pounds by building the size needed or using more than one REM for large packages.

LOCATION IN THE SHUTTLE

On the first five Shuttle flights, the REM is mounted on the DFI pallet (Fig. 2). It has the IECM mounted on "top" (Shuttle horizontal) with the RMS arm secured along the port side of the Shuttle. It is located near the upper boundary of the bay envelope which permits an unobstructed view from the aft starboard TV camera. It is also visible from the crew compartment. It cannot be viewed with the TV camera which is on the RMS arm.

The RMS attaches to the IECM mounted grapple fixture and the REM unlatches so that the IECM can be moved.

The REM is mounted with the 1-in. diameter structural pins pointing toward the starboard side of the Shuttle. The REM "front" is defined as the part nearest the Shuttle starboard side. Thus the front rail is starboard, and the pins point to the front of the REM.

On the fourth Shuttle flight, another REM unit will be mounted to the PDP. This REM releases the PDP for the collection of plasma data that is available within reach of the RMS.

On Spacelab II, about the fourteenth Shuttle flight, the REM previously flown with the PDP will again be mounted with the PDP and a spin table called the special purpose end effector (SPEE). On this mission the RMS attaches to the SPEE; the REM releases the PDP which is between the REM and the SPEE; the RMS positions the PDP for launch; and the SPEE spins the PDP and releases it. The RMS then places the SPEE, which has a set of REM rails attached, on the REM base, and the REM latches the SPEE for return in the Shuttle.

On a later mission, a PDP will be recovered from orbit and latched on a REM for return in the Shuttle.

SHUTTLE CONTROL OF THE REM

The REM and the RMS are controlled from the crew compartment. The REM is controlled from the payload retention panel (Fig. 3). It is operated by the astronaut selecting one of the two motors available in the REM and turning on the power to that motor. The REM is unlatched when the unlatch indicator is on. After the operator using the RMS moves the IECM about 1/2 in. from the REM, the position indicators on the display panel will go off. The six REM position indicators are obtained on three barber pole displays by positioning a rotary selector switch. Three positions are displayed with the selector switch is placed on "1" (also selects motor number one) and the other three positions are displayed by the same barber pole displays when the selector switch is rotated to "2" (also selects motor number 2). The REM unlatch and latch is controlled by a double throw, spring loaded, toggle switch.

REM LATCHED CONDITION

The REM is attached to the IECM (Fig. 4) or other payloads with two "L" rails having five 3/8-in. bolts for each rail (Fig. 1). The REM requires the structure of the IECM to transfer loads from the forward to aft rail. These two rails, which remain attached to the IECM when the REM is unlatched, have two each, steel pins, which carry structural

loads from the DFI pallet to the IECM. One pin on each rail is 1 in. in diameter, while the other pin on each rail is 1 in. square. The round pins fit into nut plates with approximately 0.001 in. clearance, while the square pins fit into rectangular nut plate holes that have 0.001 in. clearance "top to bottom" and approximately 3/8 in. gap right to left. The rectangular holes allow for thermal expansion and contraction along the length of the rail. The 0.001 in. clearance will be changed to 0.003 in.

Thermal expansion and contraction are provided between the front and aft rail by a 1/8-in. gap between the aft rail and the REM base structure.

The front rail is firmly pressed against the REM base structure by a latching linkage preloaded to approximately 750 lb on each pin (Fig. 5).

The latching linkage is attached to a bell crank at an angle of about 2.5° providing a mechanical advantage of 10,000 to 1. The bell crank is locked or rotated by a worm gear, differential, and gear train to the redundant electric motors (Fig. 6). These motors are locked with an electromechanical brake when the REM is not operating.

In the latch position, the aft rail has two mated electrical connectors providing power and data links to the IECM (Fig. 1).

The REM has 10 microswitches which indicate the position of REM rails relative to the REM base. Three position switches indicate that the REM rails are on the REM base ("Z" position), two switches indicate that the rails are against the REM base side ("X" position), and one switch indicates that the front rail hooks are against the linkage monoballs on the REM base. The other four switches indicate bell crank position, i.e., two for latched and two for unlatched. These switches also provide a shutoff signal to the motor power relay in the Shuttle. In the latched position, the six position indicators show barber poles on the A6 panel (Fig. 3) and the latched light is on.

REM UNLATCHED CONDITION

The REM when unlatched has the bell crank rotated 73° from latched (Fig. 7), the unlatched light on the A6 panel is on, the latched light is off and the six position indicators will be on until the rails are moved approximately 1/4 in. from the microswitches. The four 1-in. thick pins are removed from the nut plate holes on the REM base, and the two electrical connectors on the aft rail are disconnected (Fig. 8).

The REM base is freed from the REM rails allowing the RMS to move the payload which is attached to the rails.

REM REATTACHMENT PROCEDURE INCLUDING DRIVE TRAIN OPERATION

Positioning the REM rails on the REM base for latching is equivalent to placing a rectangular box in the inside corner of a dark room. The box is placed on the floor, then moved against a wall, then along the floor and wall corner to another wall. The box is then accurately positioned in the room without seeing the room or the box.

Positioning of the REM rails relative to the REM base is accomplished by the operator using the RMS.

The operator moves the IECM with the RMS in a "Z" direction until the rails contact the base (Fig. 9). He targets for a position on the base several inches from the position required for REM latching. This target is an open, clear, smooth surface.

The operator senses contact between rails and base when the RMS stops (by TV viewing or RMS rate indication). Next, the operator will move the rails forward until the rails contact the base side fence which will again stop the RMS movement. The operator then moves the rails toward the forward fence until they stop when hooks on the forward rail contact rollers which are attached through the latching linkage to the REM base. The operator at the A6 panel checks the three "Z" position indicators to see if the three rail pads are in contact with the three "Z" position microswitches. If the pads are not contacting the switches, the operator moves the rails to make contact. When the "Z" position indicator shows contact, the operator switches the rotary selector to position "2" which provides two "X" and one "Y" position indications. If these indicators do not show contact between rail end pads and microswitches, the operator moves the rails to the switches. He then rechecks the "Z" position indicators. If six indicators show contact between REM rails and REM base, the operator presses the latch switch for approximately 3 sec to operate one of the REM drive motors and latches the REM rails to the REM base (Fig. 10).

The operating motor (Fig. 6), as determined by the position of the rotary switch on the A6 panel, is running at approximately 10,000 rpm. It drives spur reduction gears through a differential to a worm and worm gear which further reduce the rotational rate. The worm gear is on a shaft which passes through the REM base, and this shaft has a bell crank on the outer end.

The bell crank is attached to linkage which transforms the rotary motion of the crank to linear motion of the four 1-in. pins connected to the rails.

During the latching operation, the pins move approximately 1.7 in. to insert them securely into the nut plate holes in the REM base.

As the bell crank approaches the latched position, it contacts two microswitches which shut off power to the motor and provide a latched signal to the A6 panel.

The operator checks the displays to verify that the REM is latched. He will note that the latched indicator is "on," the unlatched indicator is "off," and the three "Z" indicators are "on." He rotates to position "2" and sees that the "Y" and "X" indicators are on. As a backup verification, the operator checks the TV view and direct visual if available.

The operator turns the motor selector switch to an "off" position, the A6 power off, and disengages the RMS.

CONCLUSIONS

The REM in conjunction with the RMS remotely unlatches an experiment from the Shuttle bay pallets. It will be used with the IECM and the PDP. It has been proposed for use with several other experiments. It was designed by MSFC, Structures and Propulsion Laboratory, Mechanical Division, Adas James Verble, Jr., Harvey Connell, Adrian Clark, Calvin Mueller (deceased), Clarence Heller, and John Calvert. It was fabricated by MSFC's Test Laboratory.

An application for a patent has been submitted to the MSFC Patent Office. REM drawings, MSFC 30A60001 through 30A60223, are available for fabrication or evaluation of the REM for space applications.

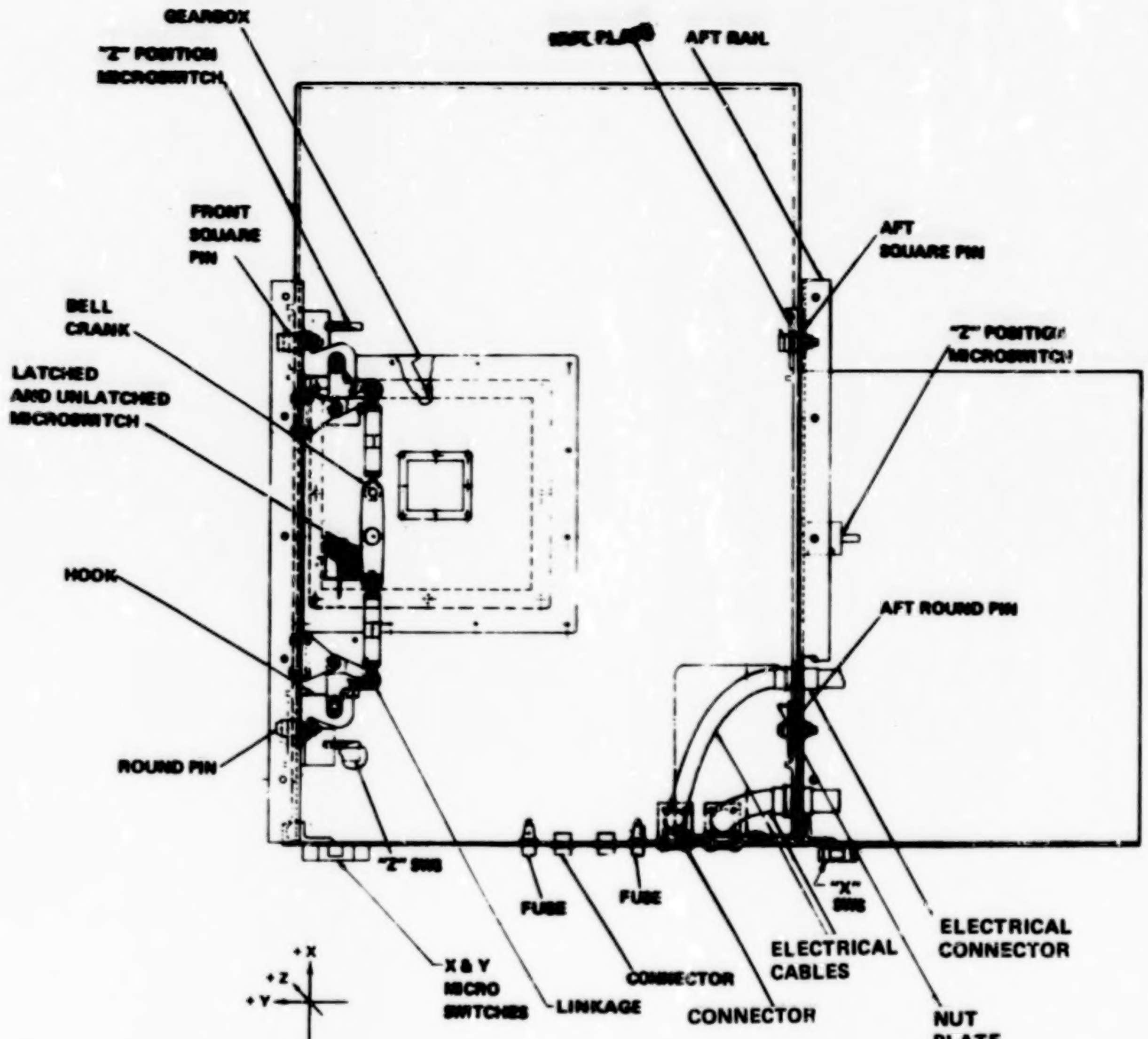
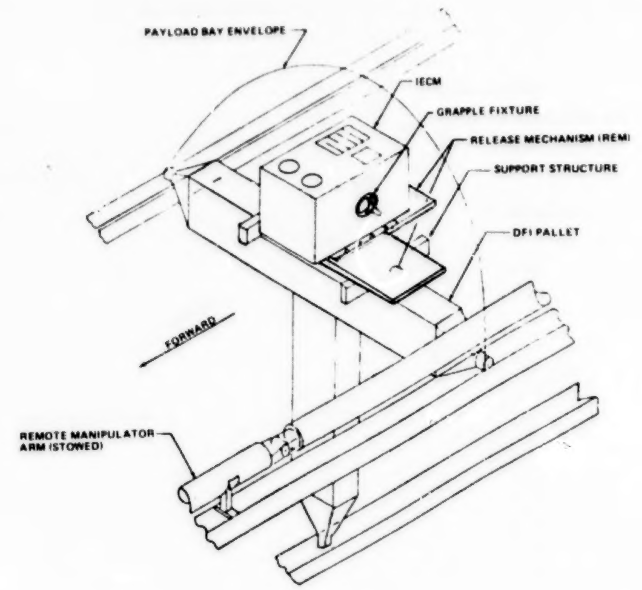
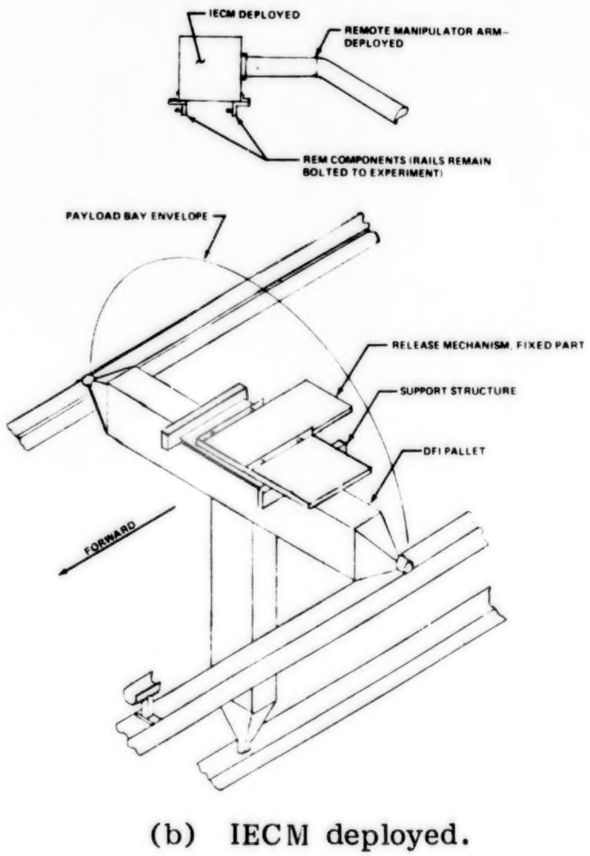


Figure 1. Release Mechanism (REM).



(a) IECM latched.



(b) IECM deployed.

Figure 2. Payload layout IECM/DFI/RMS.

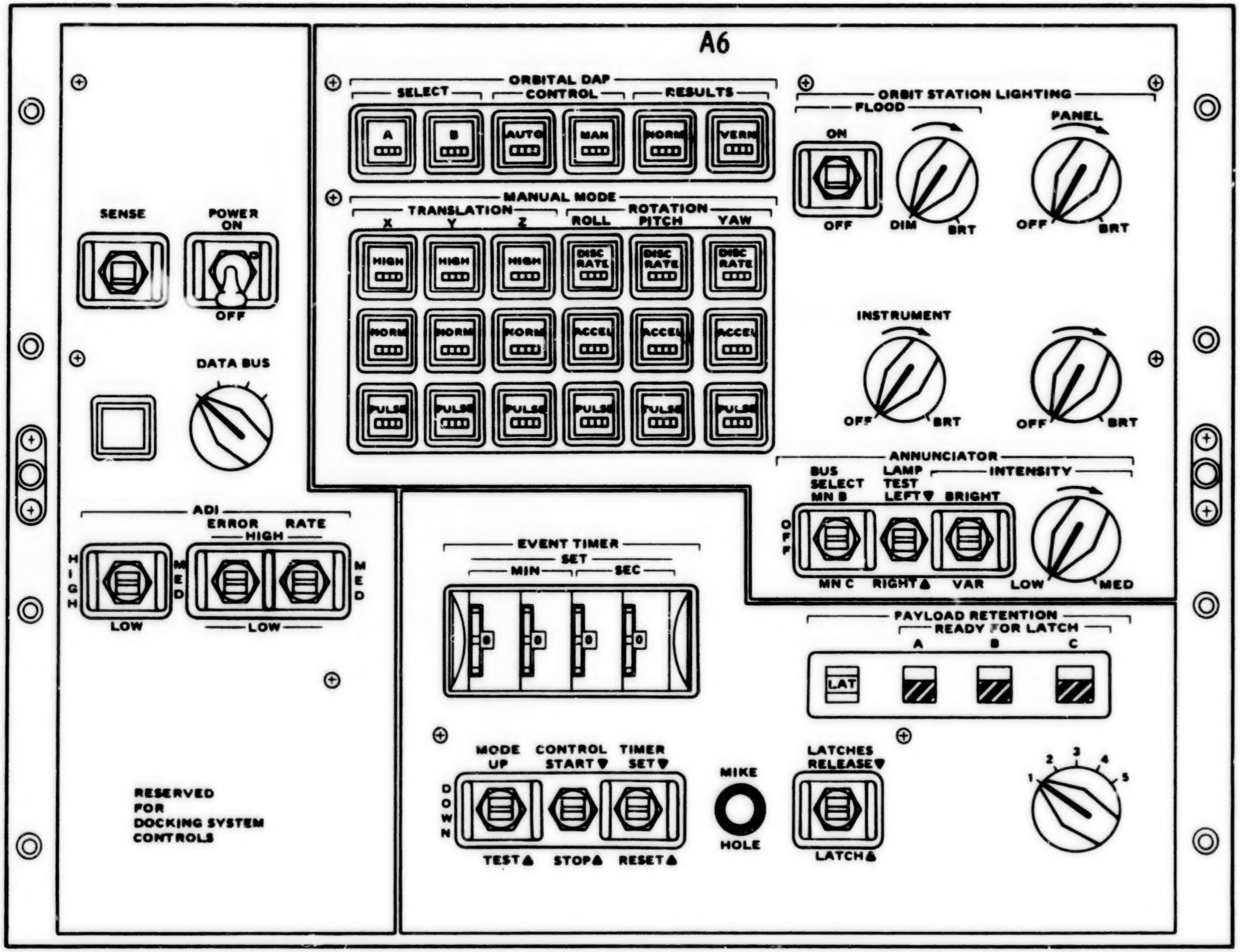


Figure 3. Payload retention panel.

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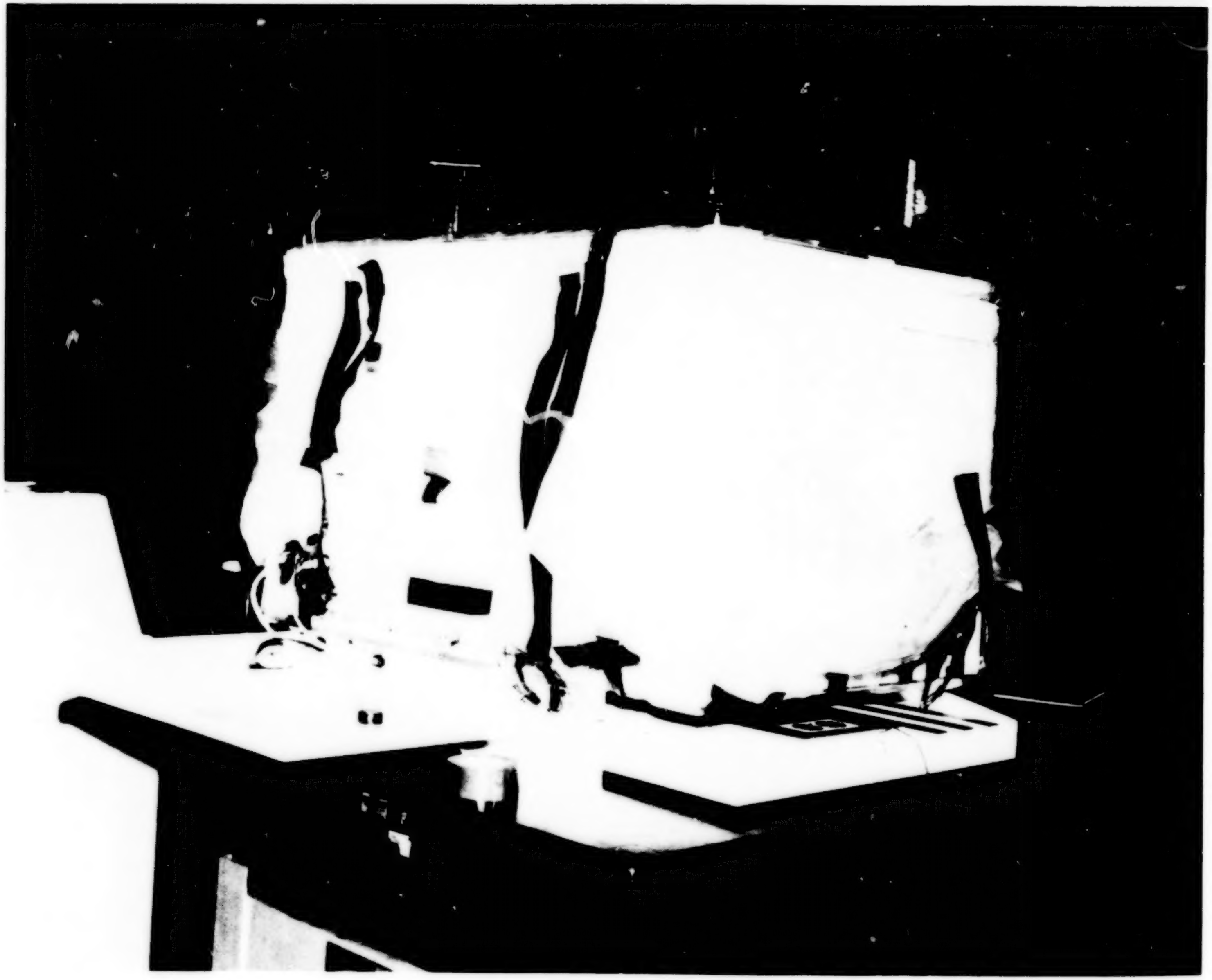

Figure 4. IECM/REM.

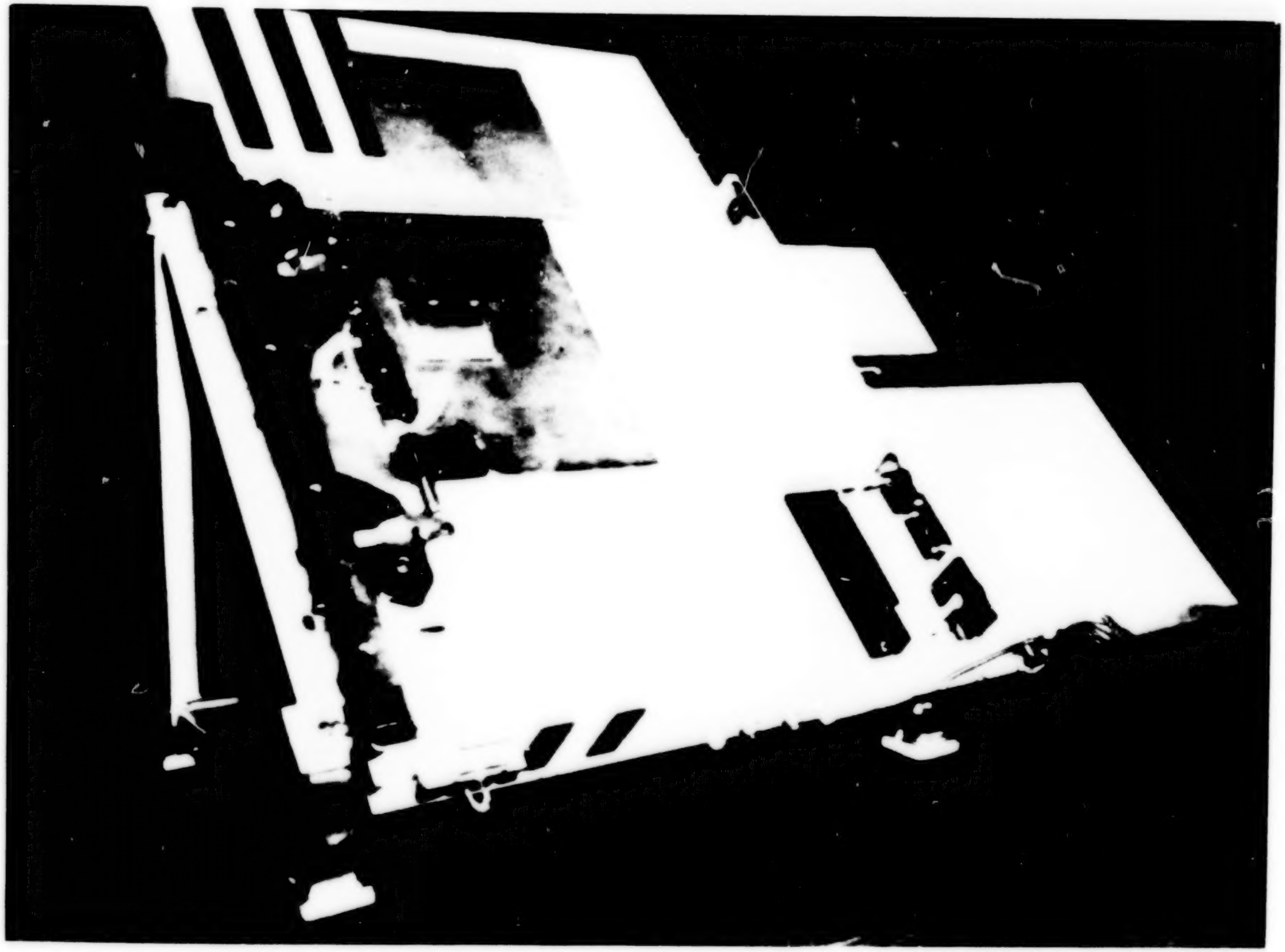

Figure 5. Front rail against REM base structure.

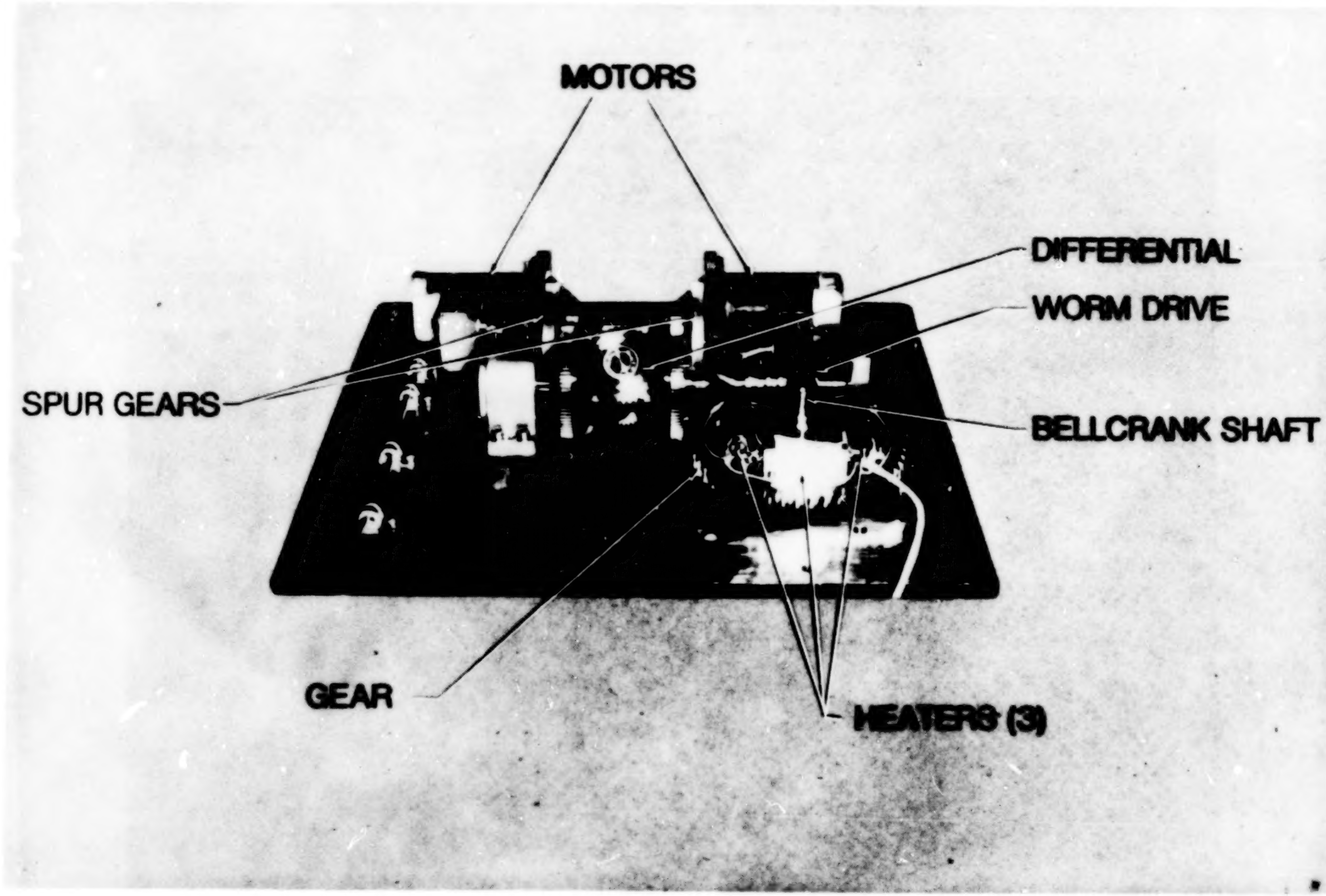

Figure 6. REM gear box.

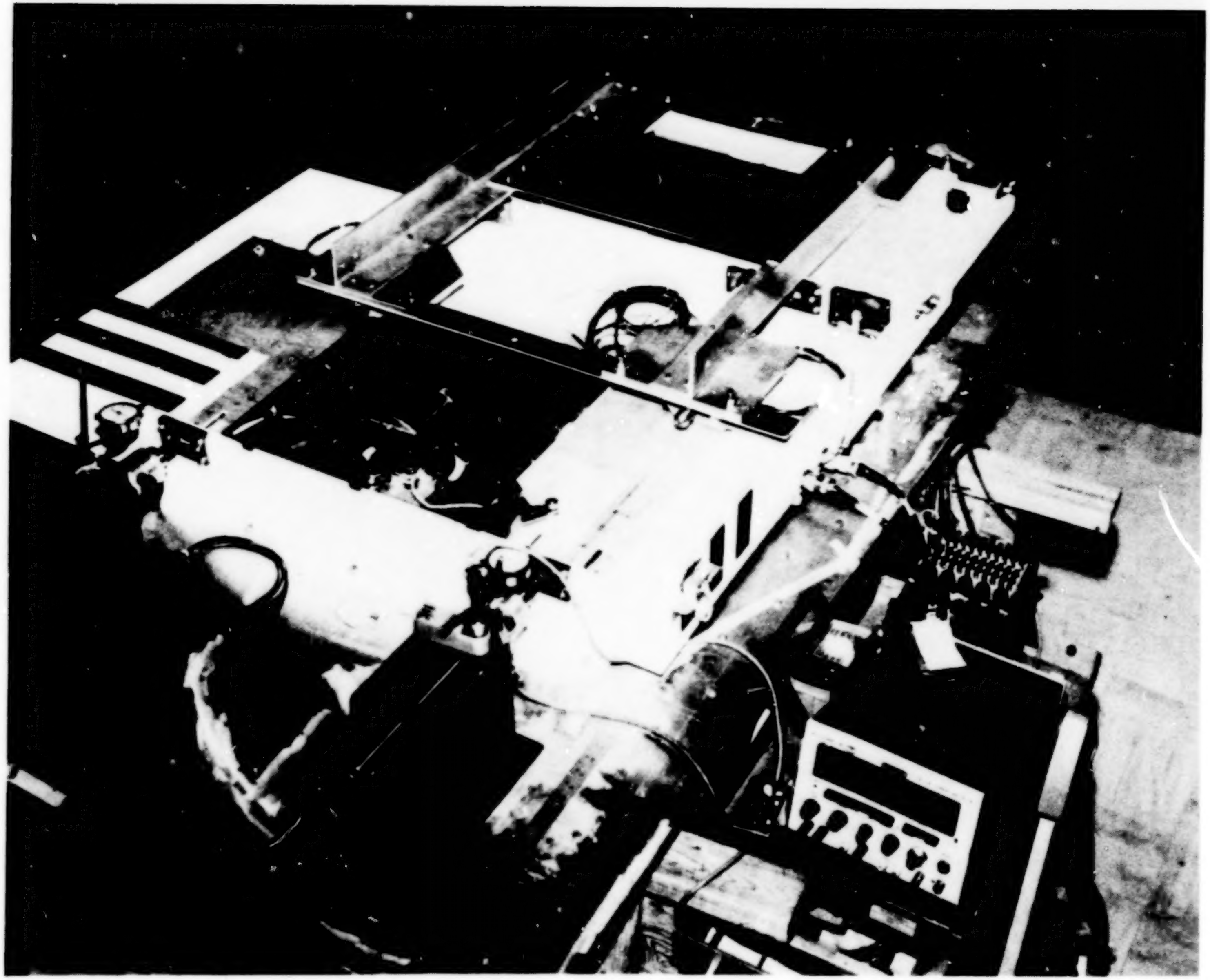

Figure 7. REM unlatched condition.

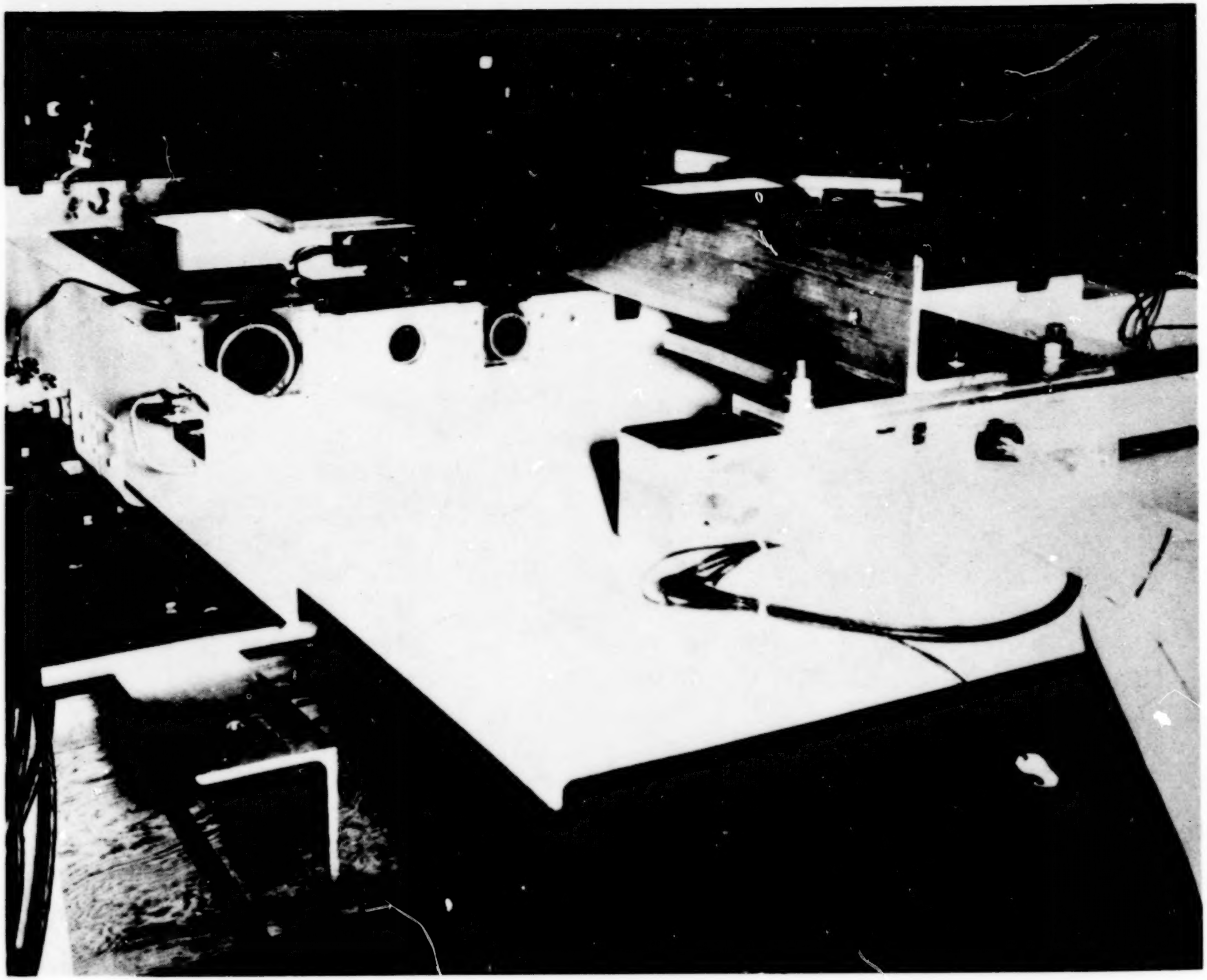

Figure 8. REM with pins removed and electrical connections disconnected.

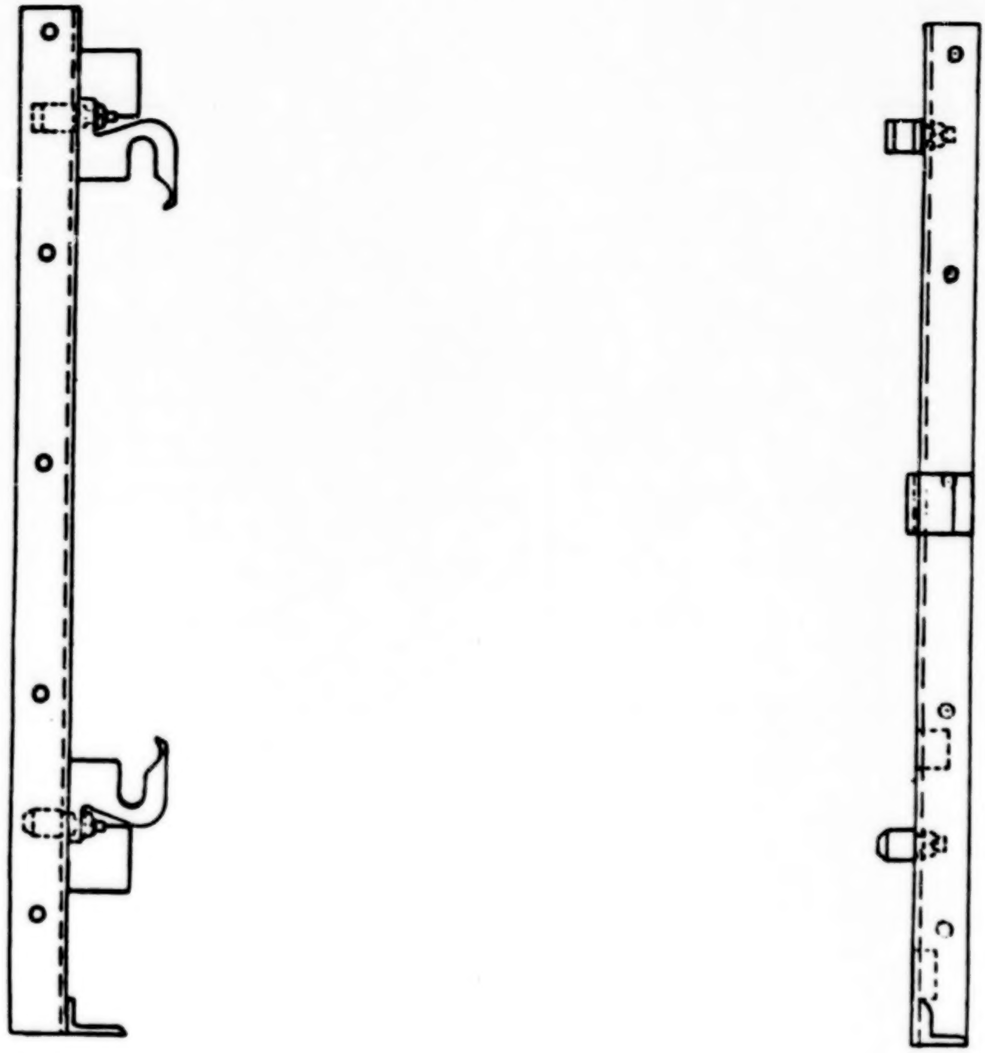

Figure 9. Rails which attach to IECM or experiment.

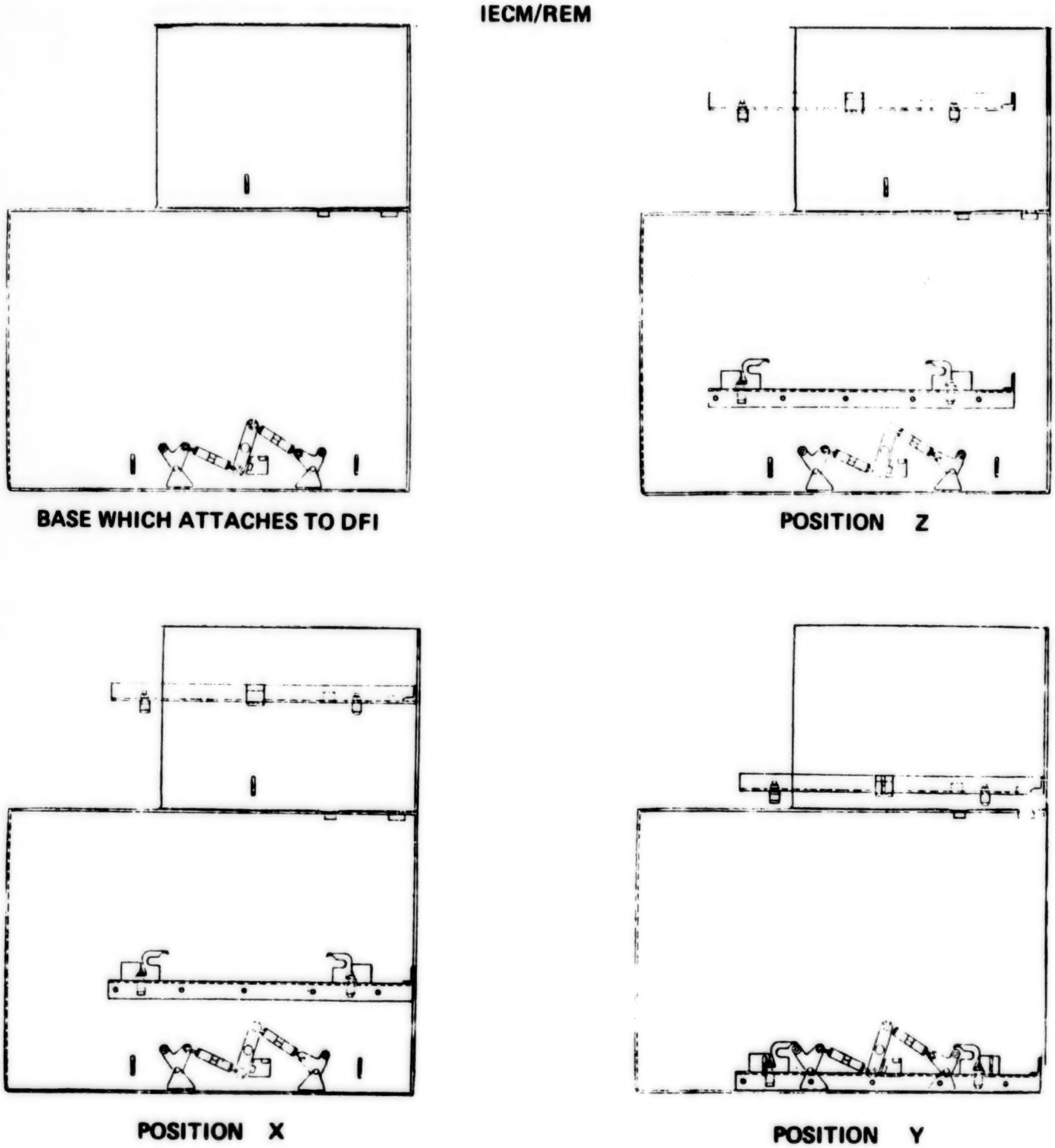

Figure 9. (Concluded).

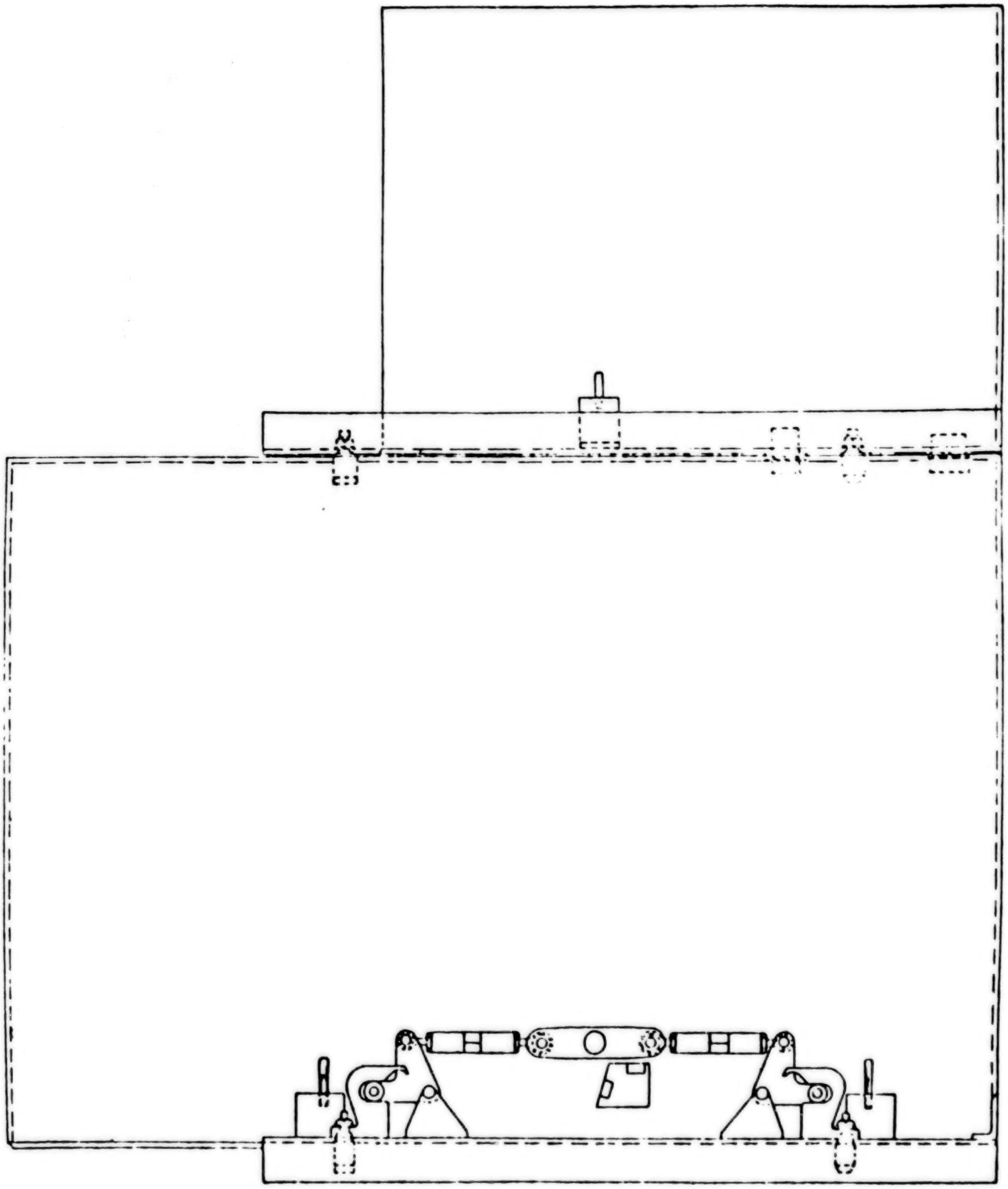

Figure 10. IECM/REM latched.

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16. ABSTRACT

The Release Mechanism (REM) unlatches an experiment so that it can be moved about inside and outside the Shuttle bay by the remote manipulator system (RMS) then reattaches it to the REM base. With the REM being operated from the crew compartment after the RMS has been attached to the experiment, the REM releases the experiment by an electric motor driving a gear train and linkage which extracts four pins from holes in four plates. Electrical connectors on the REM are disengaged by the mechanical action of the structural pins retracting from the plates.

When the REM releases the experiment, an unlatched indicator is actuated in the crew compartment, and then the experiment can be moved by using the RMS.

To reattach the experiment to the REM, the RMS places the experiment with REM attachment angles against the flat, smooth surface of the REM; then the RMS moves the experiment into position for latchup. Locating the experiment for reattachment might be analogous to finding the corner of a room in the dark when you are standing on the floor and walk to a wall, then follow the wall to a corner at (another wall).

When the REM is in the "corner" ready to be latched, indications in the crew compartment show the experiment position relative to the REM. Actuation of an electric motor drives the four pins into the four holes in the plates. When fully latched, a switch actuated by the motion of the linkage, shuts the electric motor off and gives an indication to the crew compartment that the REM is latched.

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